Investigative Results on Reciprocating Compressor Trans-Critical CO_2 Refrigeration Cycle

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Abstract: **As an environmentally first rate refrigerant, CO2 has acquired growing interest. Different establishments and businesses have superior CO2 compressors for unique packages. Some small CO2 compressors had been superior in Japan for the use in domestic warmth pump water heater and vehicle air-conditioner. The self-acting valve has a remarkable have an impact at the performance and reliability of the reciprocating compressor. In the trans-crucial CO2 cycle, the huge density and immoderate-strain distinction throughout the valve cause excessive bending and impact pressure within the valve, imparting incredible disturbing situations for a hit valve layout. In this undertaking, analytical investigations are made to determine the thermodynamic normal performance of the compressor. While various design parameter compressor pace 60m/s, 80m/s, 100m/s and 120m/s, the motion of the release valve within the reciprocating CO2 compressor is measured so as to investigate the most factors that have an impact at the valve dynamics. Three-d model of the valve is completed in Pro/Engineer and CFD assessment and thermal evaluation is finished on the discharge valve in Ansys. Thermal assessment is finished via varying the materials Stainless Steel, En8 Steel and Cast Iron.**

Keywords: **CFD Analysis; CO2 Compressors; 3D Model; EN8 Steel; Cast Iron; Pressure;**

1. INTRODUCTION

As an environmentally fine refrigerant, CO2 has received an increasing number of hobby. Different establishments and organizations have advanced CO2 compressors for unique applications. Some small CO2 compressors were superior in Japan for the use in home warmness pump water heater and automobile air-conditioner. These compressors are often scrolled and rolling piston kinds, with energy around 1-2kW and COP round 4. Large and medium CO2 compressors have been produced thru Dorin and Bock for the use in enterprise programs. Compared with traditional fluorocarbon-based totally absolutely refrigerants, CO2 has to decrease crucial temperature (31.ć) however better crucial strain (7.37MPa). Due to the transcritical operation of the cycle, the CO2 compressor is jogging underneath an awful lot better pressure, 5-10 instances better than the standard compressor. This high pressure motives massive forces, which considerably challenges the format of key additives such as crank, connecting rod, bearings and suction/discharge valves.CO2 has an excessive volumetric capacity (22.6MJ/m3 at 0ć), it without a doubt is 1.Fifty eight, 5.12 and eight.25 times as masses as NH3, R22, and R12 respectively. Thus, the swept extent of the CO2 compressor is smaller than the equal vintage compressor. So, it can be feasible to layout the compressor compact and fee-powerful compressor. However, it becomes greater tough to installation the valves with enough go with the drift region in enormously small vicinity. The immoderate strain distinction, blended with the big density of CO2, deliver super bending and impact stresses to the valves. Also, the immoderate tempo (2900rpm) of CO2 compressor reasons immoderate effect velocities. Researchers have stated that the discharge valve and the spring have fairly brief life and are clean to break due to unsuitable fabric, layout, and manufacture. Robust design of the valves is vital to enhance the reliability of the CO2 compressor. Junghyoun Kim (2006) analyzed the valve dynamics of a hermetic reciprocating compressor the use of R134a as a refrigerant. The dynamic behavior of the valves and the stress-extent diagram had been acquired. However, the released stress is a lousy lot lower than the essential strain and the belongings of the 2 refrigerants have become pretty considered one in every of a type. Jeffrey J.NIETER analyzed the discharge port and valve and the outcomes determined out immoderate over-pressure loss. Detailed experimental research about the valve dynamics for transcritical CO2 cycles is unavailable now.

2. RELATED STUDY

The excessive-strain distinction, combined with the massive density of COR 2R, convey great bending and effect stresses to the valves. Also, the excessive tempo (2900rpm) of COR 2R compressor reasons excessive impact velocities. Researchers have said that the discharge valve and the spring have a pretty quick existence and are clean to interrupt due to the incorrect material, format, and manufacture. The sturdy layout of the valves is important to enhancing the reliability of the COR 2R compressor. Junghyoun Kim (2006) analyzed the

valve dynamics of an airtight reciprocating compressor using R134a as a refrigerant. The dynamic conduct of the valves and the stress-amount diagram has been acquired. However, the discharge stress is a lousy lot lower than the vital strain and the belongings of the 2 refrigerants changed into pretty unique. In transcritical refrigeration cycles, COR 2R0T 0Toperates at loads higher pressures than traditional HFC and ammonia structures. Compressors are artwork soaking up devices which can be used for growing strain of the fluid on the fee or artwork done on fluid. The compressors used for compressing air are called air compressors. Compressors are usually used for all programs requiring excessive-stress air. Some of the well-known programs of the compressor are, for using pneumatic equipment and air operated device, spray paint, compressed air engine, supercharging floor cleaning, refrigeration, and air conditioning, chemical organisation and so forth. Compressors are supplied with low-strain air (or any fluid) at inlet which comes out as excessive-pressure air (or any fluid) at the hole. Work required for growing strain of air is available from the immoderate mover using the compressor.

Fig.2.1. CO_2compressor.

3. DESIGN AND METHODOLOGY

An unmarried level semi-airtight reciprocating CO2 compressor with two cylinders is advanced for the use in industrial organization refrigeration. The cooling capability is 29kW under the evaporation temperature of -10c Geometrical parameters Stroke-to-bore ratio has vital outcomes on the general ordinary performance of the compressor. The big stroke-to-bore ratio can also want to lessen the sealing period and as an end result, reduce the leakage. Additionally, a small bore permits proscribing the piston pressure, which may also lessen the loads at the transferring factors. However, there may be smaller vicinity left to put in the valves with enough float places. From the leakage and area issues, a stroke-to-bore ratio of 1.03 is selected. Computer-aided layout (CAD), additionally called pc-aided layout and drafting (CADD), is the use of laptop generation for the manner of layout and layout documentation. Computer Aided Drafting describes the manner of drafting with a laptop. CADD software program, or environments, provides the patron with inter-device for the cause of streamlining format techniques; drafting, documentation, and manufacturing techniques. CADD output is often in the shape of virtual documents for print or machining operations.

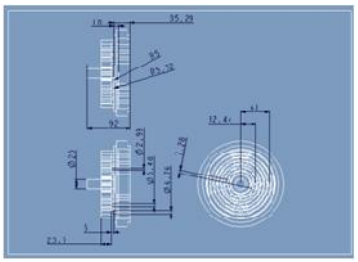

Fig.3.1. Design 2D model.

Fig.3.1. 3D model.

4. ANALYSIS RESULTS

FEA includes a laptop version of a fabric or design that is forced and analyzed for unique outcomes. It is utilized in new product format and gift product refinement. An organization is capable of verifying a proposed layout can be capable of appearing to the customer's specifications previous to manufacturing or production. Modifying a present product or shape is carried out to qualify the product or form for a modern-day provider state of affairs. In case of structural failure, FEA may be used to help determine the format modifications to fulfill the current state of affairs. FEA makes use of a complicated system of factors known as nodes which make a grid called a mesh. This mesh is programmed to encompass the material and structural houses which outline how the form will react to sure loading conditions. Nodes are assigned at a sure density in some unspecified time in the future of the fabric relying on the predicted strain stages of a selected place.

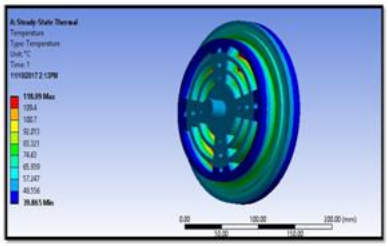

Fig.4.1. Temperature.

MATERIAL –CAST IRON:

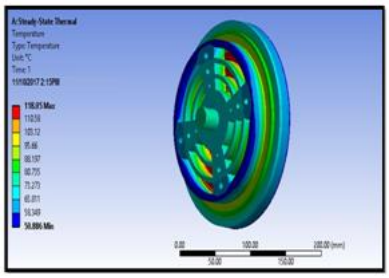

Fig.4.2. Temperature in model.

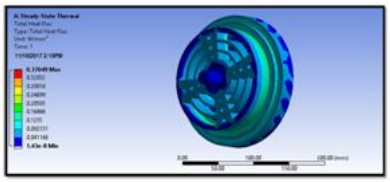

Fig.4.3. Heat flux in model.

MATERIAL –EN 8 STEEL:

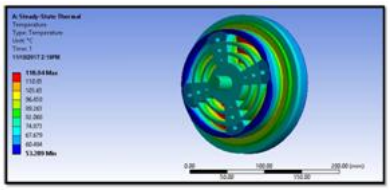

Fig.4.4. Temperature.

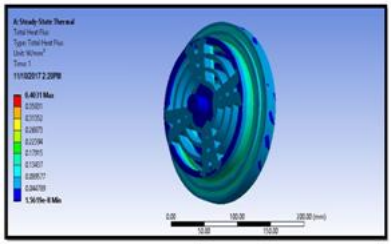

Fig.4.5. Heat flux.

CFD ANALYSIS OF RECIPROCATING COMPRESSOR DISCHARGE VALVE:

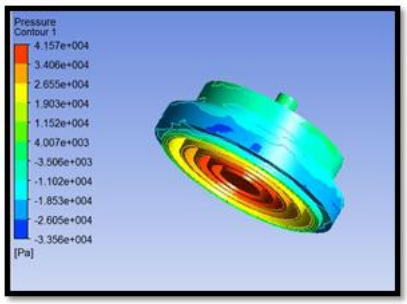

Fig.4.6. Pressure.

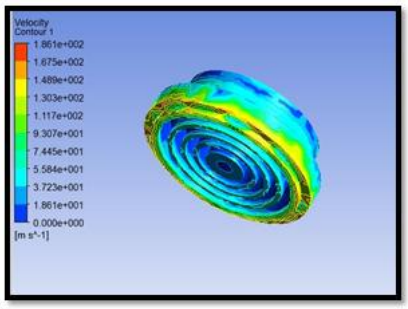

Fig.4.7. Velocity.

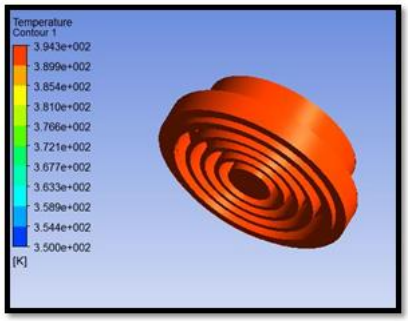

Fig.4.8. Temperature.

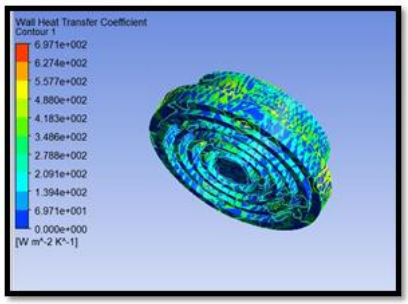

Fig.4.9. Heat transfer co-efferent.

RESULT TABLES:

Speed (m/s)	Pressure (Pa)	Velocity (m/s)	Temperature (°C)	Heat transfer co efficient (W/m²-k)	Mass flow rate (Kg/s)	Heat transfer rate (W)
60	4.157e+004	1.881e+002	3.943e+002	6.971e+002	0.017766	1517.524
80	7.404e+004	2.482e+002	3.944e+002	1.028e+003	0.025038	2138.6226
100	1.160e+005	3.100e+002	3.960e+002	1.935e+003	0.034672	3064.5356
120	1.668e+005	3.724e+002	3.949e+002	2.952e+003	0.04242	3561.9091

Fig.4.10. Results.

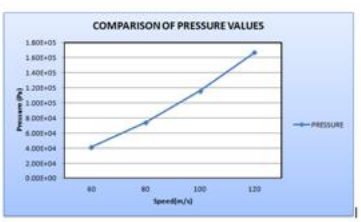

Fig.4.11. comparison of pressure values.

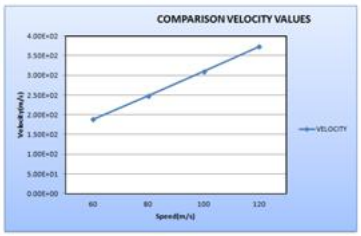

Fig.4.12. Velocity values.

Materials	Temperature(°C)		Heat flux(W/m²-K)
	Max.	Min.	
Stainless steel	118.09	39.865	0.16399
Cast iron	118.05	50.886	0.37049
EN8 steel	118.04	53.289	0.4031

Fig.4.13. Thermal Analysis Result Table

5. CONCLUSION

In this assignment, analytical investigations are made to decide the thermodynamic general regular typical overall performance of the compressor thru numerous format parameter compressor speed 60m/s, 80m/s, 100m/s and 120m/s. Three-d version of the valve is completed in Pro/Engineer and CFD evaluation and thermal evaluation are completed on the discharge valve in Ansys. Thermal assessment is finished via several the substances Stainless Steel, En8 Steel and Cast Iron. By comparing the CFD evaluation results, the warmth transfer price, warmth switch coefficient, stress, velocity, and mass flow price are advanced through the use of manner of growing the compressor tempo. By looking at the thermal analysis consequences, EN8 Steel has greater warmness flux (i.e.) the warmth transfer rate is high. So it can be concluded that growing the compressor pace and the usage of EN8 metallic is higher for higher average universal performance.

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